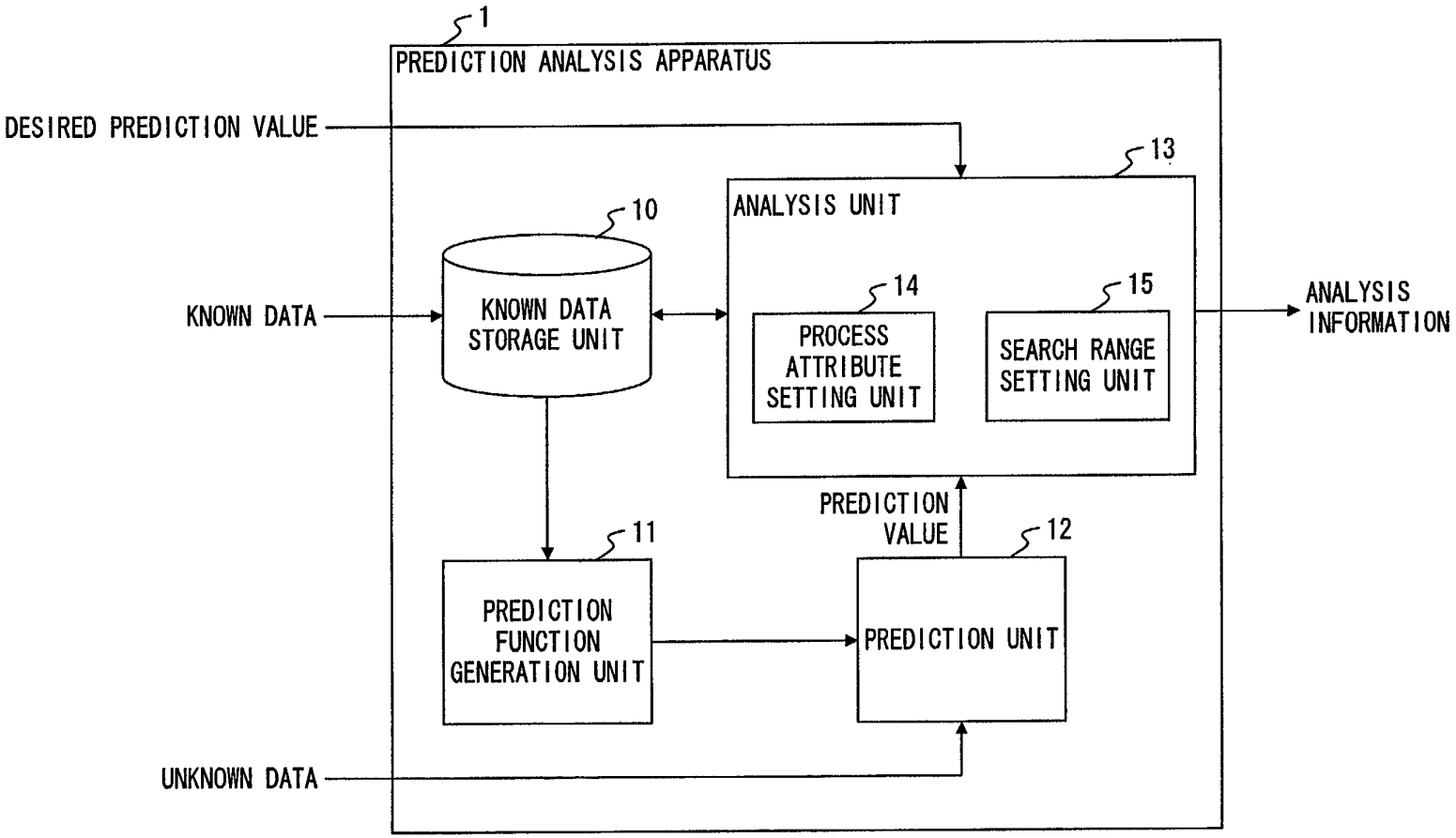

1
PREDICTION ANALYSIS APPARATUS
DESIRED PREDICTION VALUE
13
ANALYSIS UNIT
10
KNOWN DATA
KNOWN DATA STORAGE UNIT
14
PROCESS ATTRIBUTE SETTING UNIT
15
SEARCH RANGE SETTING UNIT
ANALYSIS INFORMATION
PREDICTION VALUE
11
12
PREDICTION FUNCTION GENERATION UNIT
PREDICTION UNIT
UNKNOWN DATA

FIG. 1

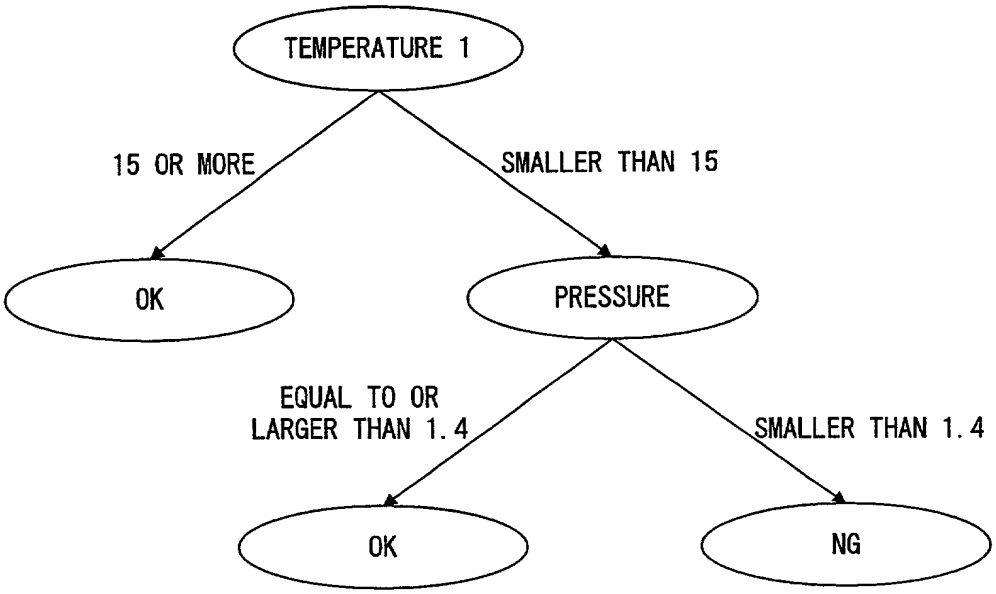


FIG. 2

[TEMPERATURE 1 ≧ 15] → OK
[TEMPERATURE 1 < 15] ∧ [PRESSURE < 1.4] → NG
[TEMPERATURE 1 < 15] ∧ [PRESSURE ≧ 1.4] → OK

FIG. 3

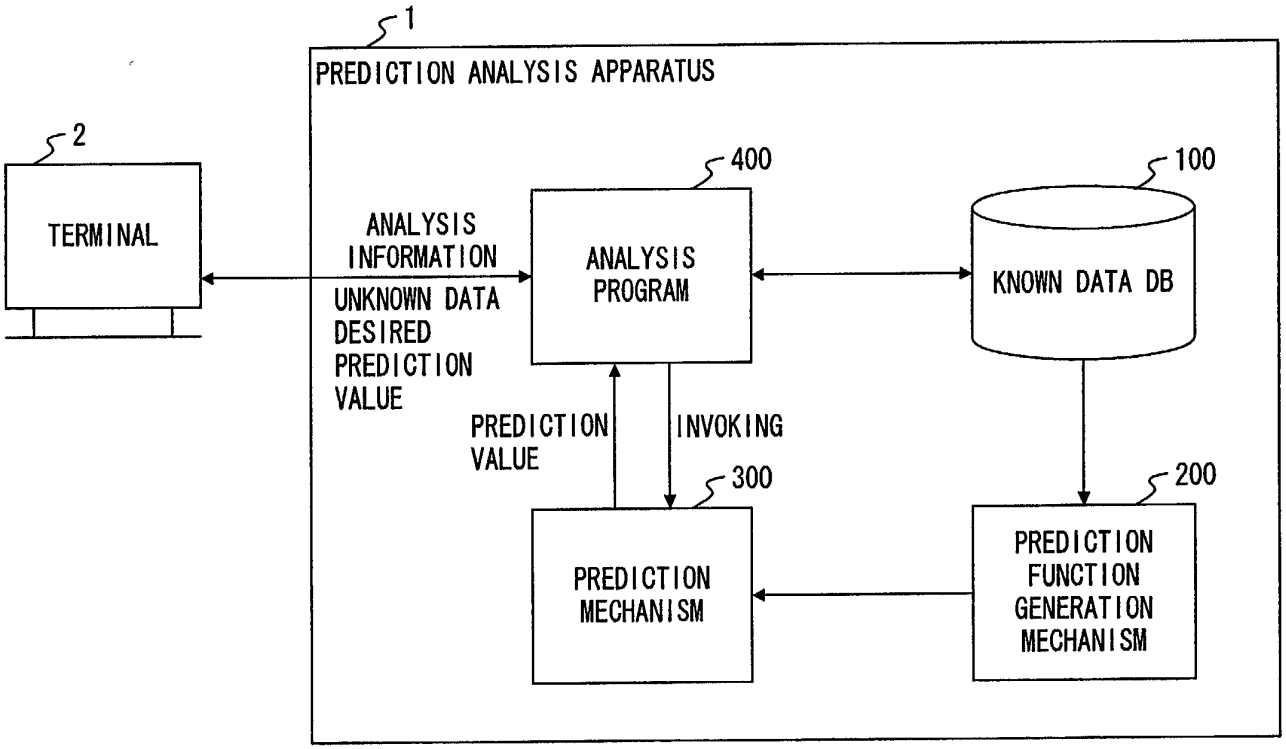

1
PREDICTION ANALYSIS APPARATUS
2
TERMINAL
ANALYSIS INFORMATION
UNKNOWN DATA
DESIRED PREDICTION VALUE
400
ANALYSIS PROGRAM
100
KNOWN DATA DB
PREDICTION VALUE
INVOKING
300
PREDICTION MECHANISM
200
PREDICTION FUNCTION GENERATION MECHANISM

FIG. 4

	TEMPERATURE 1	TEMPERATURE 2	PRESSURE	···	RESULT
No. 1	15.3	10.4	2.0	···	OK
No. 2	13.6	11.5	1.3	···	NG
No. 3	14.9	8.2	1.5	···	OK
:	:	:	:	:	:

FIG. 5A

	TEMPERATURE 1	TEMPERATURE 2	PRESSURE	···	RESULT
No. 101	13.8	8.9	1.9	···	?
No. 102	17.1	12.3	2.2	···	?
:	:	:	:	:	:

FIG. 5B

EP 0 238 860 A2

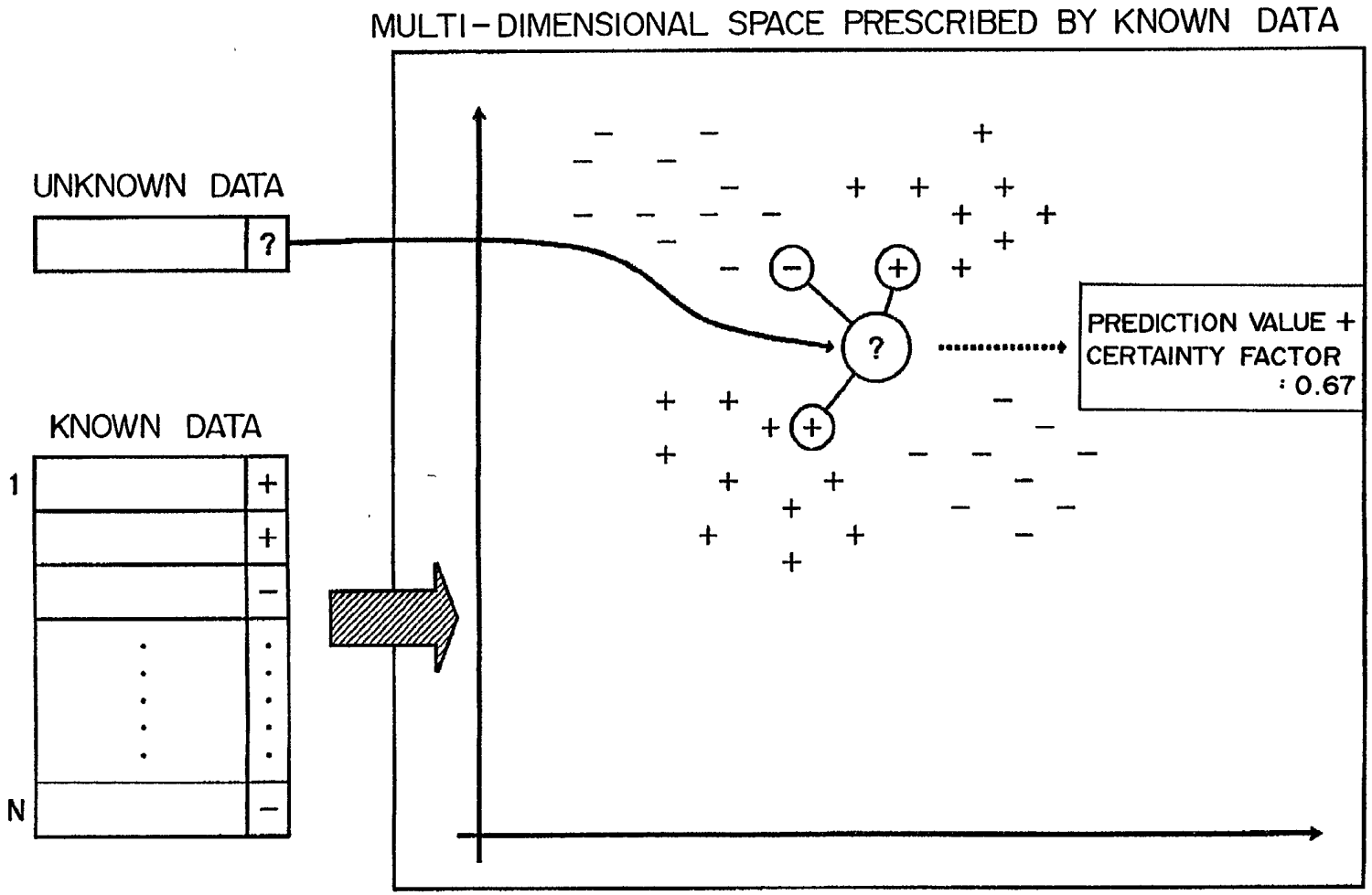


FIG. 6

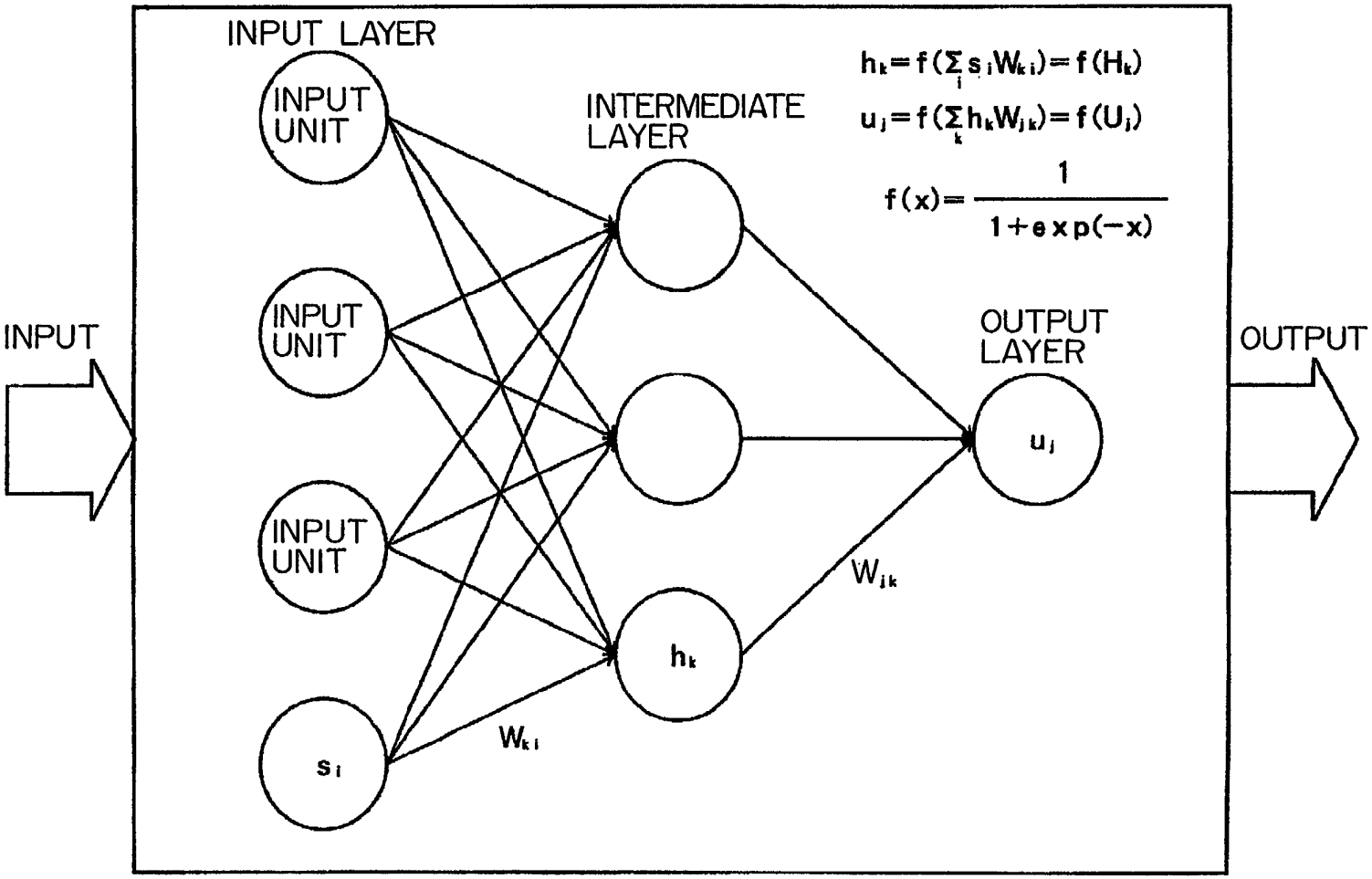
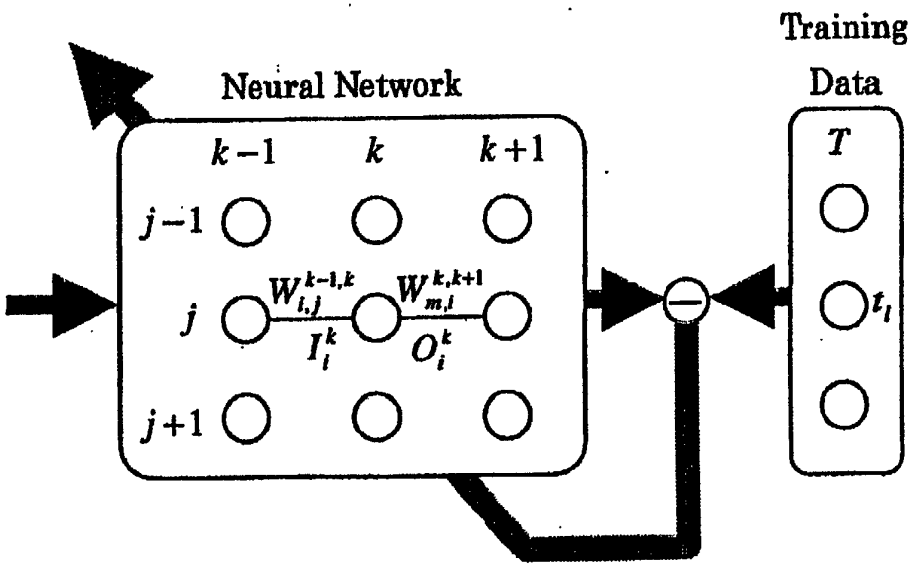

INPUT LAYER
INPUT UNIT
INPUT UNIT
INPUT UNIT
INPUT UNIT
INTERMEDIATE LAYER
OUTPUT LAYER
INPUT
OUTPUT
$h_k = f(\sum_i s_i W_{ki}) = f(H_k)$
$u_j = f(\sum_k h_k W_{jk}) = f(U_j)$
$f(x) = \frac{1}{1+exp(-x)}$
u_j
h_k
s_i
W_{ik}
W_{ki}

FIG. 7



$$I_i^k = \sum_j W_{i,j}^{k-1,k} \cdot O_j^{k-1} + \theta_i^k$$

$$O_i^k = f(I_i^k)$$

$$W \rightarrow W + \Delta W$$

$W_{i,j}^{k-1,k}$: WEIGHT BETWEEN j UNIT IN (k-1)TH LAYER AND i UNIT IN k LAYER

$W_{m,i}^{k,k+1}$: WEIGHT BETWEEN i UNIT IN k LAYER AND m UNIT IN (k+1) TH UNIT

FIG. 8

$$R = \frac{1}{2}\sum_i \left(t_i - O_i^n\right)^2$$

$$\Delta W_{i,j}^{k-1,k} = \varepsilon\left[-\frac{\partial R}{\partial W_{i,j}^{k-1,k}}\right] = \varepsilon\left[-\frac{\partial R}{\partial I_i^k}\cdot\frac{\partial I_i^k}{\partial W_{i,j}^{k-1,k}}\right] = \varepsilon\left[-\frac{\partial R}{\partial I_i^k}\right]\cdot O_j^{k-1} = \varepsilon\cdot\delta_i^k\cdot O_j^{k-1}$$

$$\Delta\theta_{i,j}^{k-1,k} = \varepsilon\left[-\frac{\partial R}{\partial \theta_{i,j}^{k-1,k}}\right] = \varepsilon\left[-\frac{\partial R}{\partial I_i^k}\cdot\frac{\partial I_i^k}{\partial \theta_{i,j}^{k-1,k}}\right] = \varepsilon\left[-\frac{\partial R}{\partial I_i^k}\right] = \varepsilon\cdot\delta_i^k$$

FIG. 9A

* IN CASE OF k = n (FINAL STAGE)

$$\delta_i^n = -\frac{\partial R}{\partial I_i^n} = -\frac{\partial R}{\partial O_i^n}\cdot\frac{\partial O_i^n}{\partial I_i^n} = \left(t_i - O_i^n\right)f'\left(I_i^n\right)$$

* IN CASE OF k ≠ n

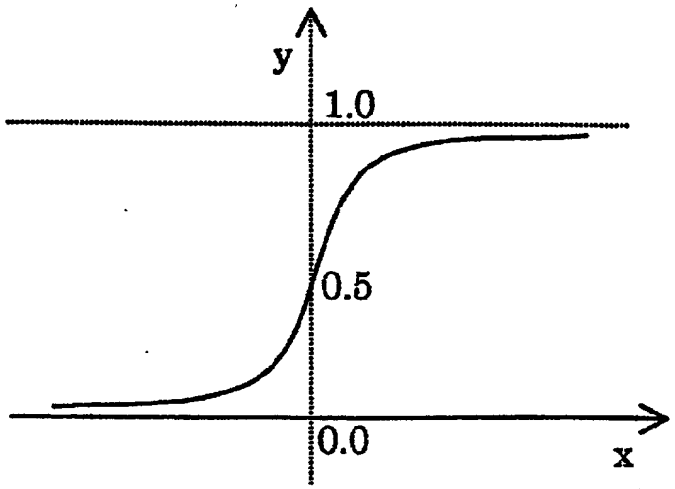
$$\delta_i^k = -\frac{\partial R}{\partial I_i^k} = -\sum_m \frac{\partial R}{\partial I_m^{k+1}}\cdot\frac{\partial I_m^{k+1}}{\partial O_i^k}\cdot\frac{\partial O_i^k}{\partial I_i^k} = -\sum_m \frac{\partial R}{\partial I_m^{k+1}}\cdot W_{m,i}^{k,k+1}\cdot f'\left(I_i^k\right) = \sum \delta_m^{k+1} W_{m,i}^{k,k+1} f'\left(I_i^k\right)$$

FIG. 9B

$$\Delta W_{i,j}^{k-1,k}(n) = \varepsilon\cdot\delta_i^k\cdot O_j^{k-1} + \alpha\cdot\Delta W_{i,j}^{k-1,k}(n-1)$$

$$\Delta\theta_{i,j}^{k-1,k}(n) = \varepsilon\cdot\delta_i^k + \alpha\cdot\Delta\theta_{i,j}^{k-1,k}(n-1)$$

FIG. 9C



$$f(x)=\frac{1}{1+\exp(-x)}$$

$$\frac{df(x)}{dx}=f'(x)=f(x)\cdot\{1-f(x)\}$$

$$\delta_i^n=(t_i-O_i^n)\cdot O_i^n\cdot(1-O_i^n)$$

$$\delta_i^k=\sum_m \delta_m^{k+1}\cdot W_{m,i}^{k,k+1}\cdot O_i^k\cdot(1-O_i^k)$$

FIG. 10

$$\Delta W_{i,j}^{k-1,k}(n) = \varepsilon \cdot \delta_i^k \cdot O_j^{k-1} + \alpha \cdot \Delta W_{i,j}^{k-1,k}(n-1) + S$$

$$\Delta \theta_{i,j}^{k-1,k}(n) = \varepsilon \cdot \delta_i^k + \alpha \cdot \Delta \theta_{i,j}^{k-1,k}(n-1) + S$$

$$S = -s \cdot \frac{1}{m} \mathrm{sgn}\left(W_{i,j}^{k-1,k}(n)\right) \cdot \left\{ \sum_{i=1,}^{m} \left| W_{i,j}^{k-1,k}(n) \right| + \left| \theta_{i,j}^{k-1,k}(n) \right| \right\}$$

S: GROWTH CONTROL ITEM

s : GROWTH CONTROL COEFFICIENT

m : NUMBER OF UNITS IN (k-1) TH LAYER

W, θ : WEIGHT, THRESHOLD

sgn(x) : FUNCTION WITH SETTINGS-1 WHEN x < 0,
0 WHEN x = 0, +1 WHEN x > 0

FIG. 11

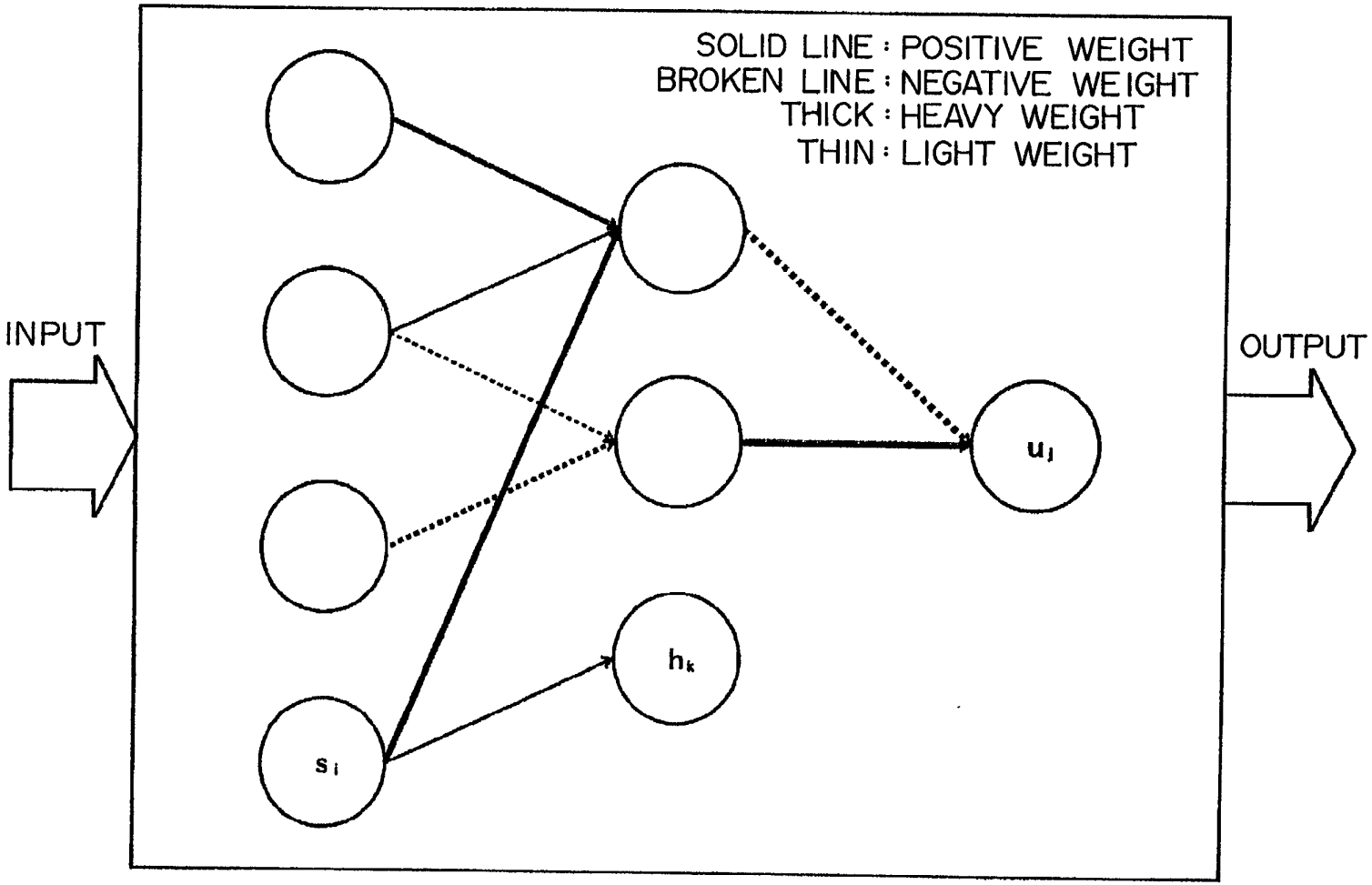

SOLID LINE : POSITIVE WEIGHT
BROKEN LINE : NEGATIVE WEIGHT
THICK : HEAVY WEIGHT
THIN : LIGHT WEIGHT
INPUT
OUTPUT
u_j
h_k
s_i

FIG. 12

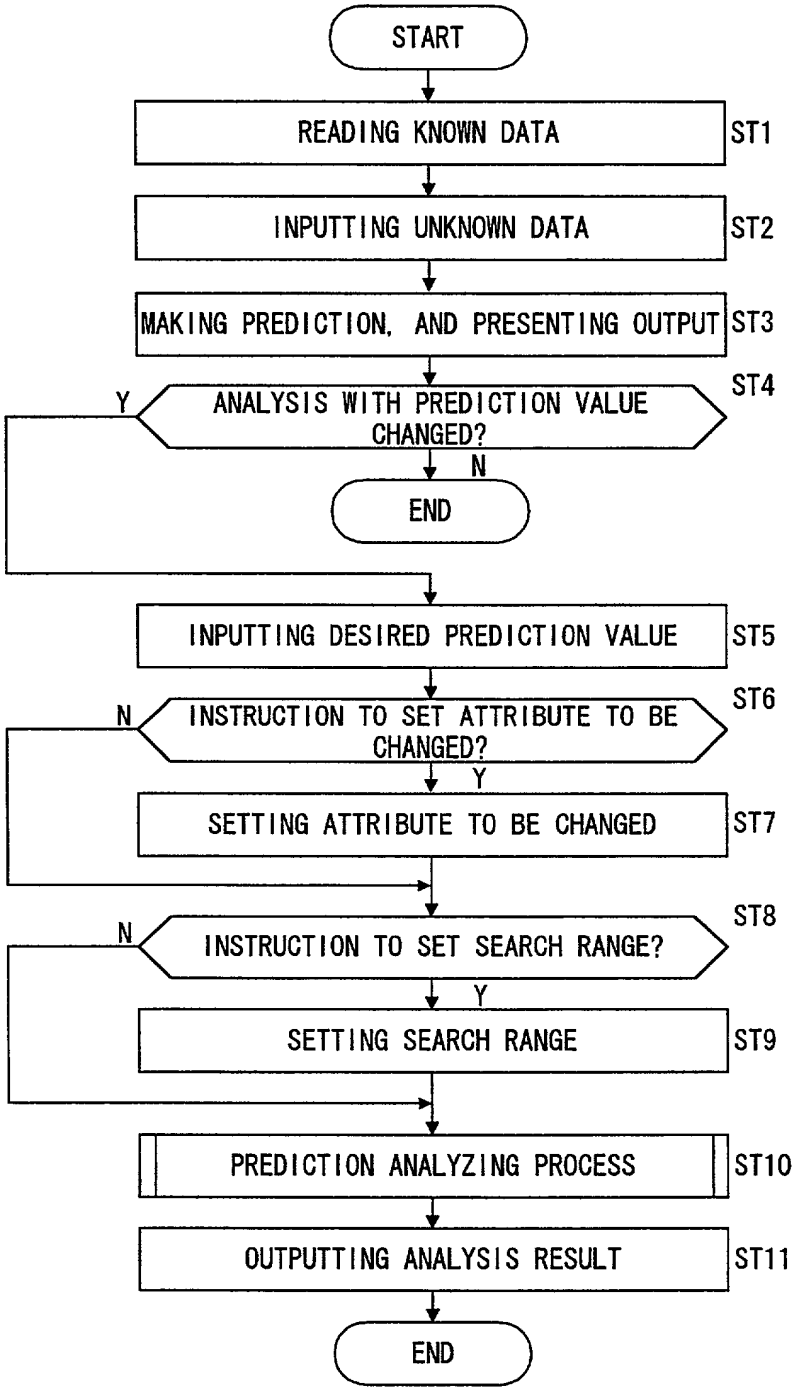

START
READING KNOWN DATA
ST1
INPUTTING UNKNOWN DATA
ST2
MAKING PREDICTION, AND PRESENTING OUTPUT
ST3
ANALYSIS WITH PREDICTION VALUE CHANGED?
ST4
Y
N
END
INPUTTING DESIRED PREDICTION VALUE
ST5
INSTRUCTION TO SET ATTRIBUTE TO BE CHANGED?
ST6
N
Y
SETTING ATTRIBUTE TO BE CHANGED
ST7
INSTRUCTION TO SET SEARCH RANGE?
ST8
N
Y
SETTING SEARCH RANGE
ST9
PREDICTION ANALYZING PROCESS
ST10
OUTPUTTING ANALYSIS RESULT
ST11
END

FIG. 13

CHANGE MARK	CHANGE	FIXED	CHANGE	···	
	TEMPERATURE 1	TEMPERATURE 2	PRESSURE	···	RESULT
No. 101	13.8	8.9	1.9	···	?

FIG. 14A

CHANGE MARK	CHANGE	FIXED	CHANGE	···	
MAXIMUM VALUE	20.0	—	2.5	···	
MINIMUM VALUE	10.0	—	1.0	···	
	TEMPERATURE 1	TEMPERATURE 2	PRESSURE	···	RESULT
No. 101	13.8	8.9	1.9	···	?

FIG. 14B

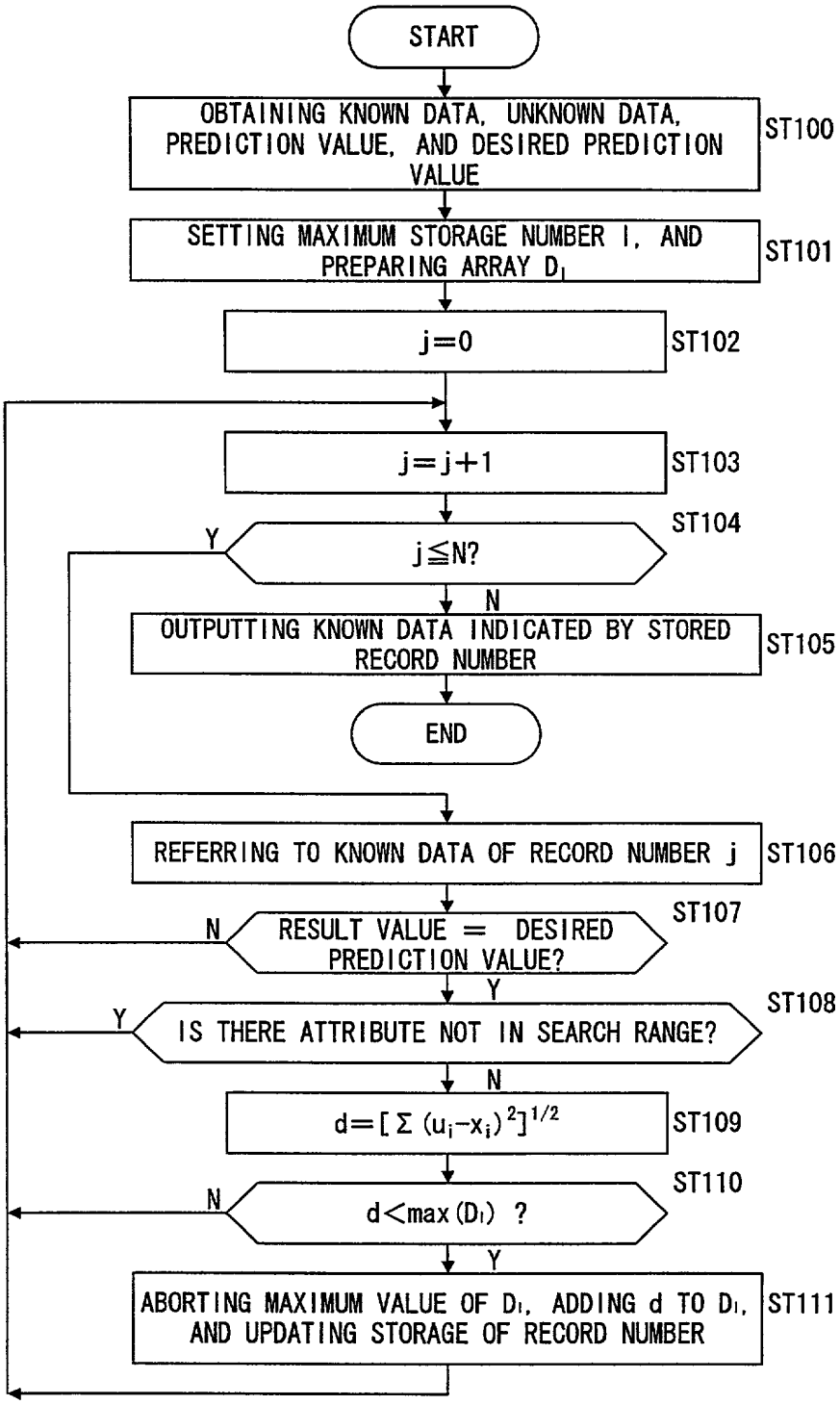

START
OBTAINING KNOWN DATA, UNKNOWN DATA, PREDICTION VALUE, AND DESIRED PREDICTION VALUE
ST100
SETTING MAXIMUM STORAGE NUMBER I, AND PREPARING ARRAY D_I
ST101
j=0
ST102
j=j+1
ST103
ST104
Y
j≦N?
N
OUTPUTTING KNOWN DATA INDICATED BY STORED RECORD NUMBER
ST105
END
REFERRING TO KNOWN DATA OF RECORD NUMBER j
ST106
ST107
N
RESULT VALUE = DESIRED PREDICTION VALUE?
Y
ST108
Y
IS THERE ATTRIBUTE NOT IN SEARCH RANGE?
N
$d=[\Sigma (u_i-x_i)^2]^{1/2}$
ST109
ST110
N
$d<\max(D_I)$?
Y
ABORTING MAXIMUM VALUE OF D_I, ADDING d TO D_I, AND UPDATING STORAGE OF RECORD NUMBER
ST111

FIG. 15

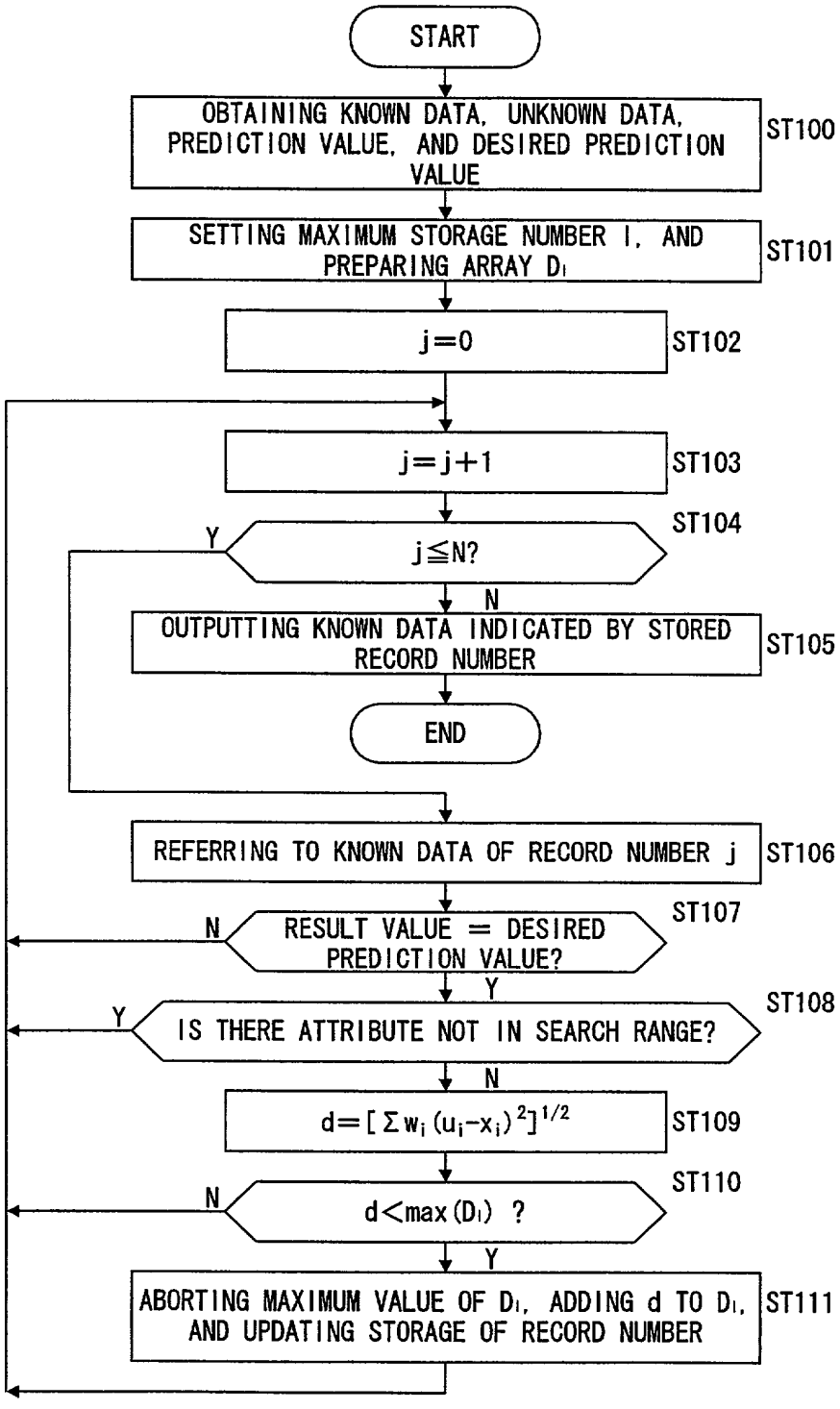

START
OBTAINING KNOWN DATA, UNKNOWN DATA, PREDICTION VALUE, AND DESIRED PREDICTION VALUE
ST100
SETTING MAXIMUM STORAGE NUMBER I, AND PREPARING ARRAY Di
ST101
j=0
ST102
j=j+1
ST103
ST104
Y
j≦N?
N
OUTPUTTING KNOWN DATA INDICATED BY STORED RECORD NUMBER
ST105
END
REFERRING TO KNOWN DATA OF RECORD NUMBER j
ST106
ST107
N
RESULT VALUE = DESIRED PREDICTION VALUE?
Y
ST108
Y
IS THERE ATTRIBUTE NOT IN SEARCH RANGE?
N
d=[Σwi(ui-xi)2]1/2
ST109
ST110
N
d<max(Di) ?
Y
ABORTING MAXIMUM VALUE OF Di, ADDING d TO Di, AND UPDATING STORAGE OF RECORD NUMBER
ST111

FIG. 16

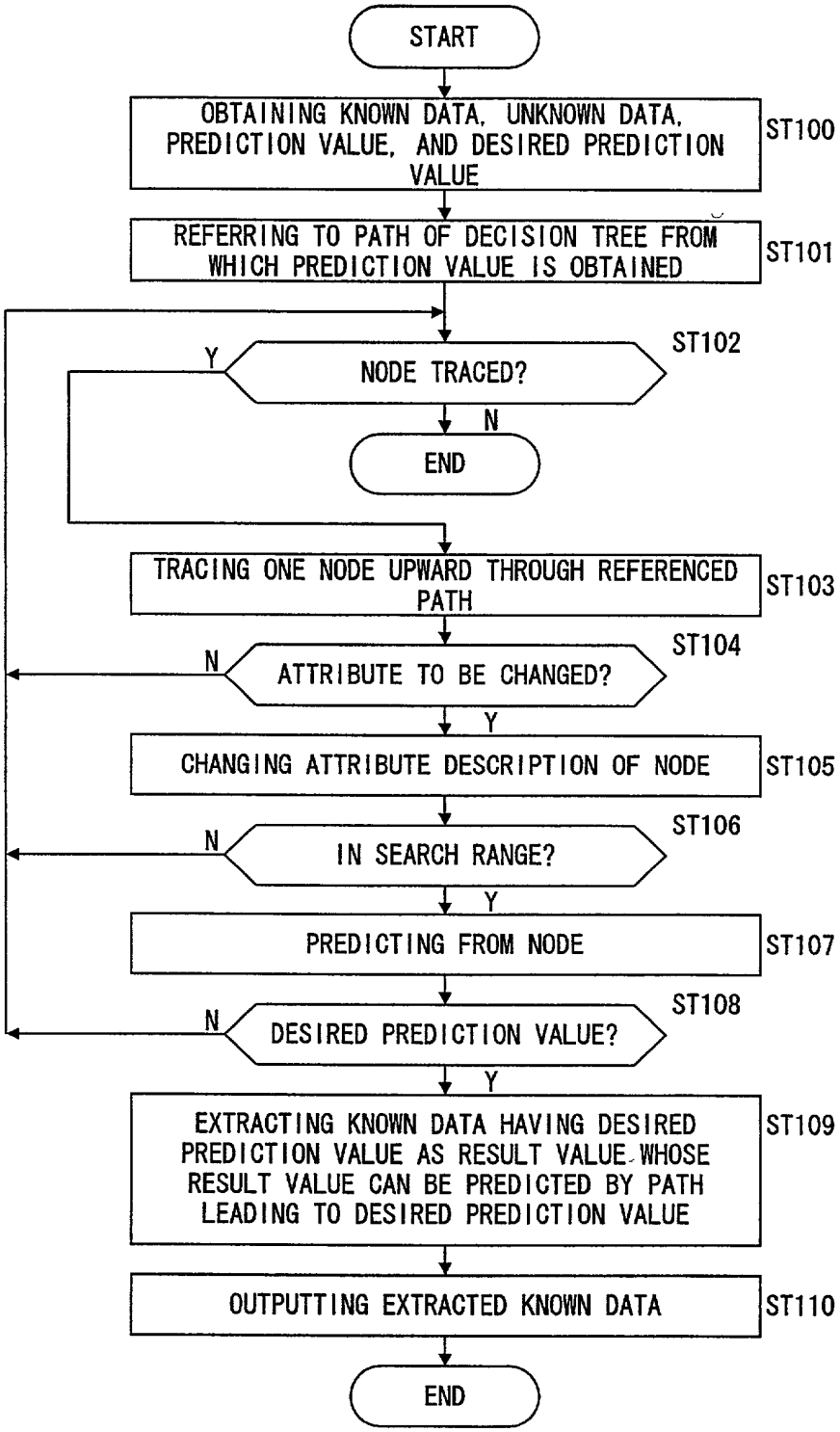

START
OBTAINING KNOWN DATA, UNKNOWN DATA, PREDICTION VALUE, AND DESIRED PREDICTION VALUE
ST100
REFERRING TO PATH OF DECISION TREE FROM WHICH PREDICTION VALUE IS OBTAINED
ST101
NODE TRACED?
ST102
Y
N
END
TRACING ONE NODE UPWARD THROUGH REFERENCED PATH
ST103
ATTRIBUTE TO BE CHANGED?
ST104
N
Y
CHANGING ATTRIBUTE DESCRIPTION OF NODE
ST105
IN SEARCH RANGE?
ST106
N
Y
PREDICTING FROM NODE
ST107
DESIRED PREDICTION VALUE?
ST108
N
Y
EXTRACTING KNOWN DATA HAVING DESIRED PREDICTION VALUE AS RESULT VALUE WHOSE RESULT VALUE CAN BE PREDICTED BY PATH LEADING TO DESIRED PREDICTION VALUE
ST109
OUTPUTTING EXTRACTED KNOWN DATA
ST110
END

FIG. 17

EP 0 736 960 A2

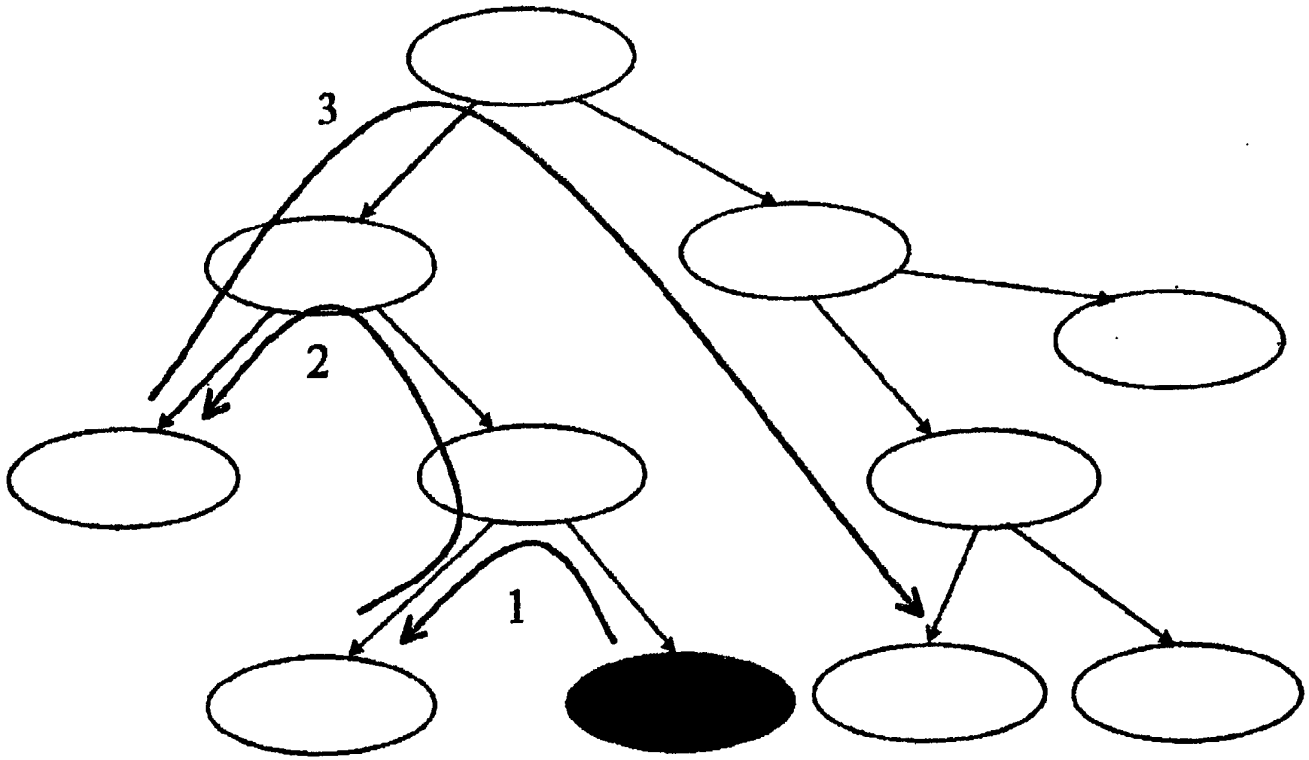


FIG. 18

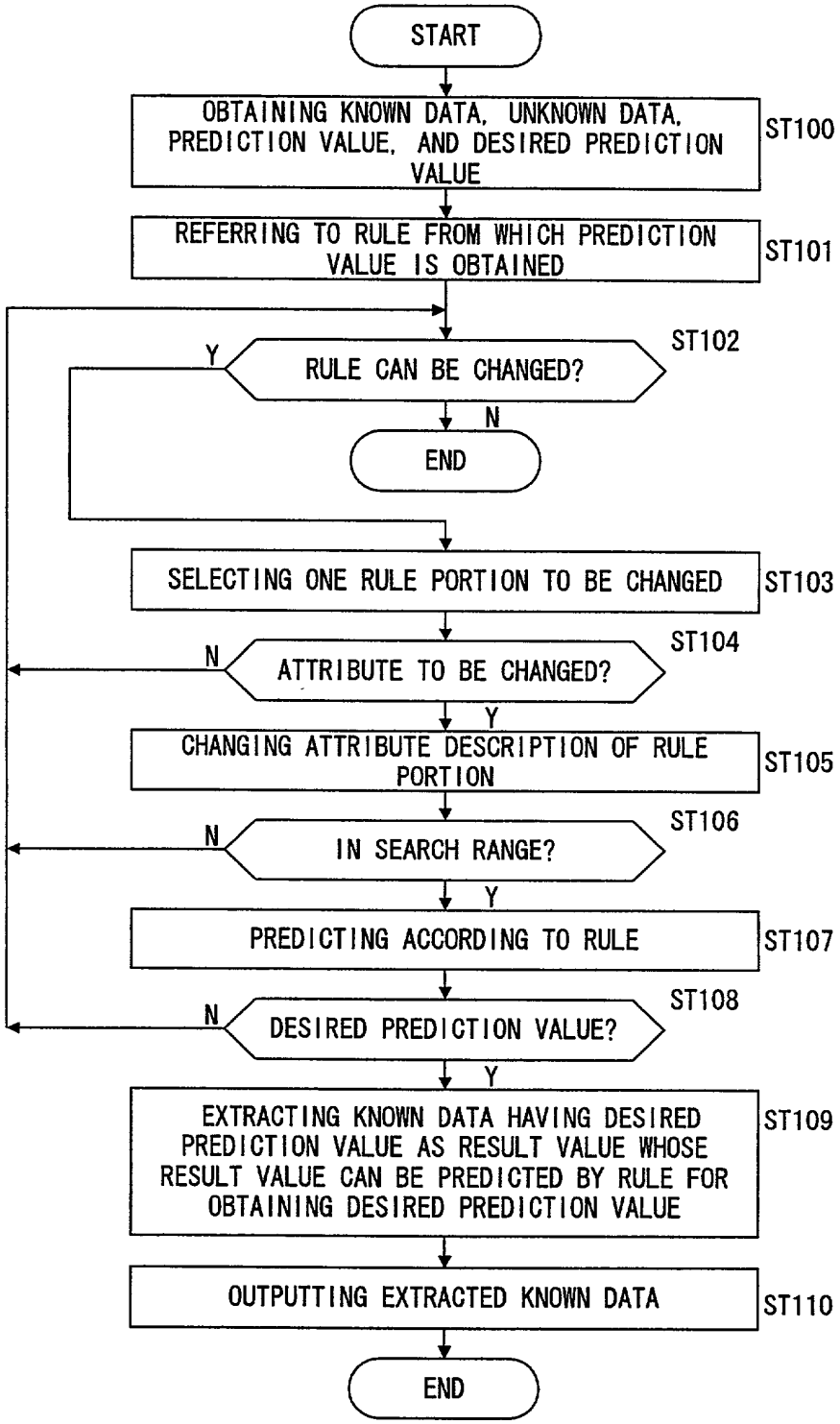
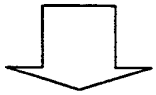

START
OBTAINING KNOWN DATA, UNKNOWN DATA, PREDICTION VALUE, AND DESIRED PREDICTION VALUE
ST100
REFERRING TO RULE FROM WHICH PREDICTION VALUE IS OBTAINED
ST101
RULE CAN BE CHANGED?
ST102
Y
N
END
SELECTING ONE RULE PORTION TO BE CHANGED
ST103
ATTRIBUTE TO BE CHANGED?
ST104
N
Y
CHANGING ATTRIBUTE DESCRIPTION OF RULE PORTION
ST105
IN SEARCH RANGE?
ST106
N
Y
PREDICTING ACCORDING TO RULE
ST107
DESIRED PREDICTION VALUE?
ST108
N
Y
EXTRACTING KNOWN DATA HAVING DESIRED PREDICTION VALUE AS RESULT VALUE WHOSE RESULT VALUE CAN BE PREDICTED BY RULE FOR OBTAINING DESIRED PREDICTION VALUE
ST109
OUTPUTTING EXTRACTED KNOWN DATA
ST110
END

FIG. 19

[A<15] ∧ [B≧1.4] ∧ [C≧10] ∧ [D≧3] → NG

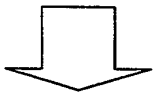
DESIRED PREDICTION VALUE = OK



CHANGING RULE

[A<15] ∧ [B≧1.4] ∧ [C≧10] ∧ [D<3] → OK?

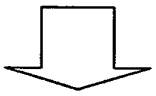
NOT DESIRED PREDICTION VALUE



CHANGING RULE

[A<15] ∧ [B≧1.4] ∧ [C<10] → OK?

NOT DESIRED PREDICTION VALUE



CHANGING RULE

[A<15] ∧ [B<1.4] → OK?

DESIRED PREDICTION VALUE

FIG. 20

EP 2 525 315 A2 20121121

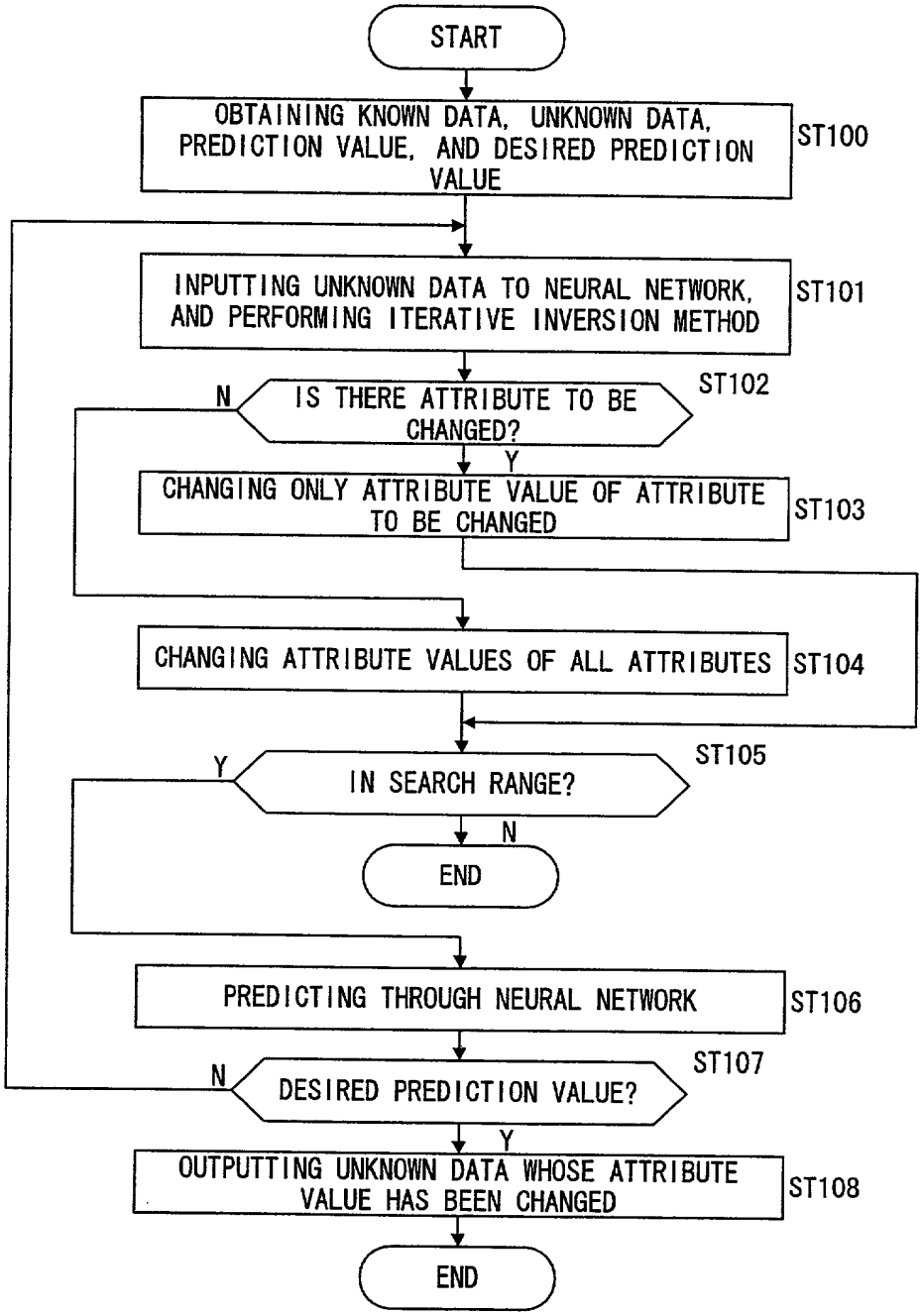
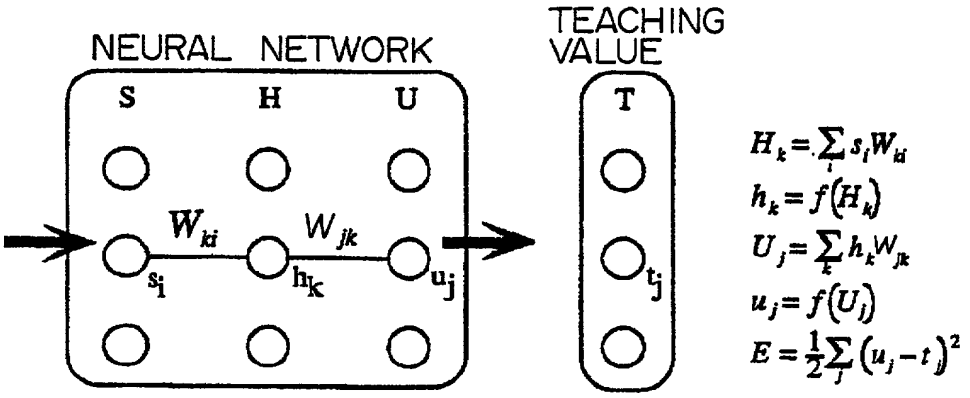

START
OBTAINING KNOWN DATA, UNKNOWN DATA, PREDICTION VALUE, AND DESIRED PREDICTION VALUE
ST100
INPUTTING UNKNOWN DATA TO NEURAL NETWORK, AND PERFORMING ITERATIVE INVERSION METHOD
ST101
IS THERE ATTRIBUTE TO BE CHANGED?
ST102
N
Y
CHANGING ONLY ATTRIBUTE VALUE OF ATTRIBUTE TO BE CHANGED
ST103
CHANGING ATTRIBUTE VALUES OF ALL ATTRIBUTES
ST104
IN SEARCH RANGE?
ST105
Y
N
END
PREDICTING THROUGH NEURAL NETWORK
ST106
DESIRED PREDICTION VALUE?
ST107
N
Y
OUTPUTTING UNKNOWN DATA WHOSE ATTRIBUTE VALUE HAS BEEN CHANGED
ST108
END

FIG. 21



$$s_i \rightarrow s_i + \Delta s_i$$

$$\Delta s_i = \varepsilon\left[-\frac{\partial E}{\partial s_i}\right] = \varepsilon\left[\sum_j (t_j - u_j)\frac{\partial u_j}{\partial s_i}\right]$$

$$\frac{\partial u_j}{\partial s_i} = \frac{df(U_j)}{dU_j}\frac{\partial U_j}{\partial s_i}$$

$$= f'(U_j)\frac{\partial\left(\sum_k h_k W_{jk}\right)}{\partial s_i}$$

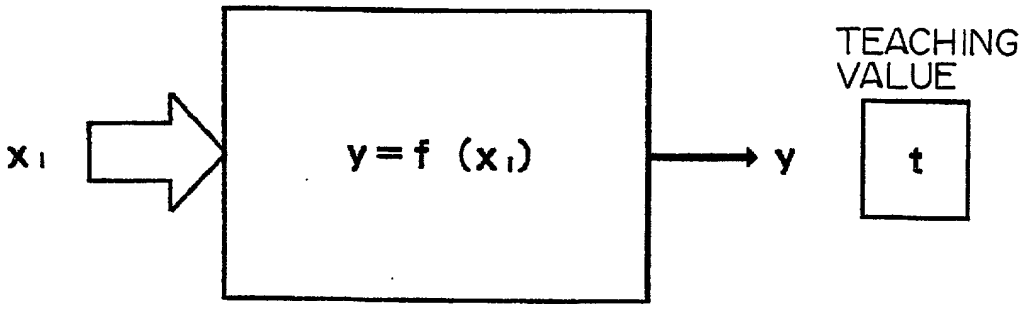
$$= f'(U_j)\sum_k W_{jk}\frac{\partial h_k}{\partial s_i}$$

$$= f'(U_j)\sum_k W_{jk}\frac{df(H_k)}{dH_k}\frac{\partial H_k}{\partial s_i}$$

$$= f'(U_j)\sum_k W_{jk} f'(H_k) W_{ki}$$

$$\Delta s_i = \varepsilon\left[\sum_j (t_j - u_j) f'(U_j)\sum_k W_{jk} f'(H_k) W_{ki}\right]$$

FIG. 22



$$E = \frac{1}{2}(y-t)^2$$

$$y = f(x_1) = \sum_i A_1 \cdot x_1$$

$$x_i \rightarrow x_i + \Delta x_i$$

$$\Delta x_i = \varepsilon\left[-\frac{\partial E}{\partial x_i}\right] = \varepsilon\left[(t-y)\cdot\frac{\partial y}{\partial x_i}\right]$$

$$\frac{\partial y}{\partial x_i} = \frac{\partial f(x_i)}{\partial x_i} = \frac{\partial \sum_i A_i \cdot x_i}{\partial x_i} = A_i$$

$$\therefore \Delta x_i = \varepsilon[(t-y)\cdot A_i]$$

FIG. 23